An Evaluation of Several Minimum Tillage Seed Drills and Nitrogen Fertilizer Placements on Seedling Development, Yield and Quality of Wheat[1]

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Seeding and fertilizing equipment has undergone a dramatic evolution since Western Canada was first settled. Researchers and farmers developed practical ways to seed and fertilize into well tilled seedbeds. Nitrogen fertilizer may be applied by preplant deep banding, seed-placing, side-banding at seeding time, or broadcasting either before or after seeding. Stand establishment may be reduced by seed placing more than 28 kg/ha urea or 45 kg/ha ammonium nitrate (Anonymous, 1986).

Minimum and zero tillage seeding has gained considerable interest in the past decade for a number of reasons. These include the availability of effective weed control chemicals, concern about soil erosion, and high operating costs of intensive tillage. There has also been an effective research and extension program demonstrating benefits of reduced tillage, and assisting farmers in adapting cost effective conservation practices.

The number of fertilizing options in minimum tillage crop production systems is quite limited. Preplant deep banding treatments are not suitable, as these banding operations leave uneven seedbed conditions that are less than optimal for seedling establishment. Additionally, a separate field operation is required to deep band, which is costly in terms of time, moisture, and the large draft requirement of the deep banding equipment. Fertilizer broadcast before direct seeding is not likely to be adequately incorporated, as most direct drilling equipment causes minimum soil disturbance. The risk of volatilization losses from post-plant broadcast treatments are well documented (Harapiak et al, 1986).

The most desirable fertilizing option in terms of seedbed condition, fertilizer efficiency and fuel efficiency, is to sideband at seeding time. The present study was set out with two major objectives. The first was to evaluate seeding with different seed opener designs (offset double disc, hoe, sweep and one-way discer) in terms of stand establishment. The second objective was to determine the relative benefits and costs of banding fertilizer at different depths.

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MATERIALS AND METHODS

Field experiments were seeded at Swift Current, Eston, Saskatoon and Rosthern in the spring of 1988 and again in 1989. The soils at these sites are identified as Swinton silt loam, Regina heavy clay, Sutherland clay and Oxbow loam respectively. Leader wheat was sown at Swift Current, while Katepwa was used in the other locations. Nitrogen fertilizer was applied as urea (46-Ø-Ø) and phosphate as mono-ammonium phosphate (11-51-Ø), or the two products were applied as a blend (such as 27-27-Ø).

Five seed implements were evaluated. They were the Versatile Noble 22ØØ hoedrill (VN), the Conserva Pak hoe airseeder (CP), the Conserva Pak airseeder equipped with sweeps (CP Sweeps), the Swift Current Zero Till offset double disc drill (SCØT), and a one-way discer (Discer, evaluated at Swift Current and Eston only).

Each implement was evaluated both with and without fertilizer, and SCØT was also used to test different depths of midrow banding as well as a post-plant broadcast treatment. The VN and CP side band fertilizer, CP Sweeps and Discer provide an "incorporated broadcast" effect, while SCØT can place fertilizer both with the seed and in midrow bands between alternate rows (Table 1). Fertilizer rates varied from test to test, and were determined from soil test recommendations. The recommendation for Saskatoon in 1989 was Ø kg/ha N, so treatments in this test refer to seed-placed or banded 11-51-Ø only.

Table 1. Seed drill and fertilizer placement combinations evaluated with spring wheat, 1988-89

drill	fertilizer placement
SCØT	no fertilizer
SCØT	11-51-Ø with seed, 46-Ø-Ø broadcast postemergently
SCØT	11-51-Ø with seed, 46-Ø-Ø midrow band 5 cm deep
SCØT	11-51-Ø with seed, 46-Ø-Ø midrow band 1Ø cm deep
SCØT	blend 11-51-Ø and 46-Ø-Ø midrow band 1Ø cm deep
VN	no fertilizer
VN	blend 11-51-Ø and 46-Ø-Ø sidebanded
CP	no fertilizer
CP	blend 11-51-Ø and 46-Ø-Ø sidebanded
CP Sweeps[1]	no fertilizer
CP Sweeps	blend 11-51-Ø and 46-Ø-Ø incorporated broadcast
Discer[2]	blend 11-51-Ø and 46-Ø-Ø incorporated broadcast

[1] Not evaluated at Swift Current
[2] Not evaluated at Saskatoon or Rosthern

Each treatment was replicated four times, in a randomized complete block design at each location. Plots were at least 30 m in length, and yields were measured from a full length cut with a 1.25 m Hege plot combine. Emergence was evaluated by counting two 1 m sections of row within each plot and calculating to a square meter basis. Grain protein was measured on a sample from each plot.

RESULTS AND DISCUSSION

1) Seedling Establishment

The only clear indication of fertilizer influencing plant stand occurred at Eston. Seed-placed P_2O_5 significantly increased stands in 1988, and fertilizer reduced stands in 1989 (Tables 2 and 3).

When drills are compared over all fertilizer treatments, SCØT provided plant stands at least equal to any other drill in six of the eight tests. The Discer, only used in four tests, gave unsurpassed stands in all except at Eston in 1988. In this instance, there may have been too much moisture loss associated with seeding, together with insufficient packing. The VN drill gave optimal stands at Swift Current, but in five of the other six tests, seedling establishment was reduced. Similarly, stands were reduced in CP treatments in five tests, and in CP Sweeps treatments in six tests. The poor seedling stands from the hoe drills, as compared to the SCØT drill, is somewhat at odds with reports from similar experiments (Tessier and Dyck, 1988; Lindwall, 1989).

Table 2. Effects of seed and fertilizer placement on stand of spring wheat, 1988

Placement		Swift Current	Eston	Saskatoon	Rosthern
		plants / m^2			
SCØT	Ø	147	125	18Ø	173
SCØT	P w seed N broad	147	15Ø	191	195
SCØT	P w seed N mid 5 cm	14Ø	141	182	187
SCØT	P w seed N mid 1Ø cm	142	158	NE	185
SCØT	all fert. mid 1Ø cm	155	127	179	172
VN	Ø	144	81	134	146
VN	blend sideband	145	85	123	153
CP	Ø	93	73	13Ø	2Ø8
CP	blend sideband	1Ø2	71	123	212
CP Sweeps	Ø	NE	1Ø2	129	178
CP Sweeps	blend	1Ø6	8Ø	117	173
Discer	blend	146	58	NE	NE
Mean		133	1Ø2	151	18Ø
LSD		25	18	35	45

NE = Not evaluated

Table 3. Effects of seed and fertilizer placement on stand of spring wheat, 1989

Placement	Swift Current	Eston	Saskatoon	Rosthern
	plants / m^2			
SCØT Ø	163	193	229	189
SCØT P w seed N broad	163	175	226	188
SCØT P w seed N mid 5 cm	165	171	NE	206
SCØT P w seed N mid 10 cm	172	151	NE	195
SCØT all fert. mid 10 cm	183	165	208	183
VN Ø	179	129	194	170
VN blend sideband	202	131	170	185
CP Ø	154	164	217	182
CP blend sideband	164	178	232	165
CP Sweeps Ø	NE	157	220	154
CP Sweeps blend	163	169	220	158
Discer blend	199	177	NE	NE
Mean	173	163	208	180
LSD	30	31	36	

NE = Not evaluated

The results presented in Tables 2 and 3 do not show temporal differences in emergence and growth. Table 4 summarizes fresh weight accumulation at two locations in 1989 as an indication of seedling vigour. Seedlings in plots seeded with CP Sweeps were clearly far behind in growth, although fertilizer overcame the differences at Saskatoon. Phosphate fertilizer availability was also important.

Table 4. Effects of seed and fertilizer placement on seedling fresh weights of ten seedlings approximately 24 days after seeding at Saskatoon and Rosthern, 1989

Placement	Saskatoon	Rosthern
	g	
SCØT Ø	522	653
SCØT P w seed N broad	289	920
SCØT P w seed N mid 5 cm	NE	885
SCØT P w seed N mid 10 cm	NE	1105
SCØT all fert. mid 10 cm	523	733
VN Ø	575	681
VN blend sideband	586	871
CP Ø	420	710
CP blend sideband	592	952
CP Sweeps Ø	462	448
CP Sweeps blend	593	438
Mean	515	752
LSD	146	279

NE = Not evaluated

2) Yield

Fertilizer increased yields in six of the eight tests, and had no effect in two (Tables 5 and 6). There were difference among drills in four tests. SCØT and Discer treatments gave equal or better yields than any other drill in these four tests. CP Sweeps treatments gave significantly reduced yields in three of eight tests.

Yields on broadcast N treatments were often lower than from banded treatments. There were no significant differences in yield between 5 and 1Ø cm deep midrow bands, but sidebanding rather than seedplacing the P2O5 reduced yields in two tests.

Table 5. Effects of seed and fertilizer placement on yield of spring wheat, 1988

Placement		Swift Current	Eston	Saskatoon	Rosthern
		kg / ha			
SCØT	Ø	82Ø	58.3	68Ø	147Ø
SCØT	P w seed N broad	786	8Ø.4	63Ø	216Ø
SCØT	P w seed N mid 5 cm	7Ø5	8Ø.1	79Ø	224Ø
SCØT	P w seed N mid 1Ø cm	717	1Ø6.1	NE	221Ø
SCØT	all fert. mid 1Ø cm	755	72.2	73Ø	185Ø
VN	Ø	738	58.8	54Ø	13ØØ
VN	blend sideband	69Ø	43.6	78Ø	2Ø1Ø
CP	Ø	7Ø7	47.Ø	56Ø	171Ø
CP	blend sideband	69Ø	43.1	75Ø	266Ø
CP Sweeps	Ø	NE	52.5	55Ø	15ØØ
CP Sweeps	blend	72Ø	58.9	86Ø	231Ø
Discer	blend	772	62.8	NE	NE
Mean		736	63.7	68Ø	196Ø
LSD			31.2	136	46Ø

NE = Not evaluated

Table 6. Effects of seed and fertilizer placement on yield of spring wheat, 1989

Placement	Swift Current	Eston	Saskatoon	Rosthern
	kg / ha			
SCØT Ø	1590	1790	1510	1850
SCØT P w seed N broad	2030	1970	1500	2200
SCØT P w seed N mid 5 cm	2310	2140	NE	2340
SCØT P w seed N mid 1Ø cm	2190	2240	NE	2250
SCØT all fert. mid 1Ø cm	2410	2110	1430	2440
VN Ø	1340	1800	1490	1940
VN blend sideband	2440	2090	1470	2300
CP Ø	1360	1610	1400	1750
CP blend sideband	2450	1970	1490	2220
CP Sweeps Ø	NE	1690	1440	1580
CP Sweeps blend	2280	1870	1470	2080
Discer blend	2370	2030	NE	NE
Mean	2070	1940	1470	2090
LSD	306	160		228

NE = Not evaluated

3) Protein Concentration and Content

Tables 7 and 8 present mean grain protein percentages of treatments at Eston, Saskatoon and Rosthern. Protein was significantly increased by N fertilization in five of the six experiments. In general, protein content was negatively related to yield. Broadcast N treatments tended to give higher protein contents than other treatments with the SCØT drill. This is an indication that the N was not available until late in the growing season.

Protein yield (grain yield x grain protein percentage) is one way of looking at fertilizer efficiency. There were significant differences in protein yield in the same five experiments as there were differences in protein percentage(Table 9)At Eston and Saskatoon, protein yield was reduced in the broadcast treatment. At Rosthern, however, fertilizer efficiency of broadcast N as measured by protein yield, was not lower than that of the banding treatments. The SCØT treatment with all fertilizer in 1Ø cm deep midrow bands appears to have had poor availability in 1988, and high availability in 1989. There is no clear benefit to banding fertilizer deeper than 5 cm.

Table 7. Effects of seed and fertilizer placement on protein percentage of spring wheat, 1988

Placement	Eston	Saskatoon	Rosthern
	---------	protein %	---------
SCØT 0	18.8	19.3	14.7
SCØT P w seed N broad	19.4	19.7	17.9
SCØT P w seed N mid 5 cm	19.4	19.3	17.8
SCØT P w seed N mid 10 cm	19.2	NE	17.7
SCØT all fert. mid 10 cm	19.3	19.5	17.1
VN 0	18.6	19.3	15.3
VN blend sideband	19.3	19.5	17.6
CP 0	18.8	19.2	15.0
CP blend sideband	18.9	19.1	18.3
CP Sweeps 0	18.7	19.2	15.1
CP Sweeps blend	19.2	19.4	18.1
Discer blend	19.1	NE	NE
Mean	19.0	19.4	16.8
LSD	0.5	0.5	0.8

NE = Not evaluated

Table 8. Effects of seed and fertilizer placement on protein percentage of spring wheat, 1989

Placement	Eston	Saskatoon	Rosthern
	---------	protein %	---------
SCØT 0	15.4	20.5	14.3
SCØT P w seed N broad	16.5	20.9	17.8
SCØT P w seed N mid 5 cm	16.7	NE	16.8
SCØT P w seed N mid 10 cm	16.2	NE	16.9
SCØT all fert. mid 10 cm	17.4	21.0	16.8
VN 0	15.4	20.5	14.8
VN blend sideband	16.7	20.9	17.1
CP 0	15.7	21.0	15.2
CP blend sideband	17.1	20.8	16.6
CP Sweeps 0	15.5	20.9	14.4
CP Sweeps blend	16.9	20.7	17.5
Discer blend	17.7	NE	NE
Mean	16.4	20.8	16.2
LSD	0.9		1.6

NE = Not evaluated

Table 9. Effects of seed and fertilizer placement on protein yield of spring wheat, 1988 and 1989

Placement	1988			1989	
	Eston	Stoon	Rosthern	Eston	Rosthern
	kg / ha				
SCØT 0	10.9	131	216	275	265
SCØT P w seed N broad	15.6	125	387	325	391
SCØT P w seed N mid 5 cm	15.5	153	397	358	392
SCØT P w seed N mid 10 cm	20.2	NE	390	362	380
SCØT all fert. mid 10 cm	13.9	142	317	363	408
VN 0	10.8	104	213	279	286
VN blend sideband	8.4	152	353	350	392
CP 0	8.8	108	257	253	265
CP blend sideband	8.1	144	486	338	372
CP Sweeps 0	9.8	106	227	264	227
CP Sweeps blend	11.3	166	417	314	362
Discer blend	12.0			360	
Mean	12.1	131	334	318	340
LSD	5.7	43	76	30	46

NE = Not evaluated

SUMMARY

Replicated field experiments were carried out at four locations over two years. The SCØT and Discer seeded treatments most frequently gave the best plant stands and yields. The CP Sweeps treatment, which is similar in design to many cultivator air seeders, most often provided reduced seedling stands and yields. The two hoe drills were intermediate in effectiveness. Studies will continue in an effort to detect fertilizer efficiency and yield differences among seed drills.

In terms of fertilizer efficiency, there is no apparent benefit to banding more than 5 cm deep. Banding depth effects on yield have not been consistent so far.

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